GLOBAL $SO_x$, $NO_x$ and $CO_2$ CAPS
CHALLENGES AND TRENDS IN MARITIME ENERGY MANAGEMENT

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Shipping Air Emissions and Its Impacts

Figure 8.1 Schematic diagram of the overall impacts of emissions from the shipping sector on climate change (from Lee et al., 2009a)

(Source: IMO 2nd GHG Study, 2009)
Motivation and Drivers (Why?)

- Environmental impact of Air Pollutants and GHGs (climate change, externalities, ....)

- More stringent environmental regulations (Paris Agreement ?, MARPOL Annex VI Chapter 3 (SOx, NOx, ..) & Chapter 4 (GHG))

- Volatile fuel oil price

- World population, energy demand and prices

- Energy resources scarcity and Energy security

- UN2030 Agenda (SDGs 7, 12 & 13 in particular)

Key Pillars of Maritime Energy Management

- Regulatory framework
- Energy efficiency
- Renewable/cleaner energy
- Technology and innovation
- Human factors
- Economics of energy management

Regulation 13 – NO$_x$ Emission Limits

Tier I
- Constructed on or after 1 Jan. 2000

Tier II
- Constructed on or after 1 Jan. 2011

Tier III*
- Constructed on or after 1 Jan. 2016
- Applied in ECAs
- Tier II applied outside of ECAs

* For a ship operating within North American ECA and US Caribbean Sea Area ECA

(Source: WMU Maritime Energy Management Specialization EGY102 Lecture Notes)
NO$_x$ Regulations

- **Tier I** emission limits apply to all marine diesel engines with a power output of more than 130 kW installed on ships constructed on or after 1 January 2000 and prior to 1 January 2011.

- Emission limits equivalent to Tier I may apply to marine diesel engines with a power output of more than 5,000 kW and a per cylinder displacement at or above 90 litres installed on a ship constructed on or after 1 January 1990 but prior to 1 January 2000 according to regulation VI/13.7.

- **Tier II** emission limits apply to all marine diesel engines with a power output of more than 130 kW installed on ships constructed on or after 1 January 2011.

- **Tier III** emission limits apply to all marine diesel engines with a power output of more than 130 kW installed on ships, operating in a NO$_x$ emission control area, constructed on or after the date of adoption of the NECA (or a later date as may be specified in the amendment to the Convention designating the NECA, whichever is later).

(Source: WMU Maritime Energy Management Specialization EGY102 Lecture Notes)
Tier III

Emission Control Areas (ECAs) for NO\textsubscript{X} Emission Control

Reg. 13.5.1:

Tier III controls apply only to the specified ships while operating in ECAs established to limit NO\textsubscript{X} emissions, outside such areas the Tier II controls apply.

- North America ECA + US Caribbean ECA for ships constructed on or after 1 January 2016
- Baltic Sea and North Sea ECAs for ships constructed on or after 1 January 2021.

(Source: WMU Maritime Energy Management Specialization EGY102 Lecture Notes)
North Sea and Baltic Sea NECAs

- MEPC 70 approved North Sea and Baltic Sea as an ECA-NOx

- This will require marine diesel engines to comply with Tier III NOx emission limit when installed on ships constructed on or after 1 January 2021 and operating in North Sea and Baltic Sea

- MEPC 70 agreed to the need for exemption provisions to allow ships fitted with dual fuel engines or with only Tier II engines to be built, converted, repaired and/or maintained at shipyards located in NOx Tier III ECAs

(Source: WMU Maritime Energy Management Specialization EGY102 Lecture Notes)
Regulation 14 - Sulphur Oxides (SOx) and Particulate Matter

From 19 May’05, Sulphur Oxide (SOx) emission from ships is controlled by setting a limit of 4.5% on sulphur content of Marine Fuels.

From 1 January 2012, the global sulphur limit of marine fuels reduced to 3.5%.

From 1 January 2020, the global sulphur limit of marine fuels reduced to 0.5%.

A number of agreed ECA-SOx has been set up.

The sulphur limits in ECA-SOx are more stringent and currently at 0.1% sulphur.

(Source: WMU Maritime Energy Management Specialization EGY102 Lecture Notes)
Regulation 14 - Fuel Sulphur Limits

Fuel oil
% sulphur

<table>
<thead>
<tr>
<th>Date</th>
<th>Sulphur Percentage</th>
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<tr>
<td>1.1.2012</td>
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<tr>
<td>1.1.2015</td>
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</tr>
<tr>
<td>1.1.2020</td>
<td>0.50</td>
</tr>
<tr>
<td>1.1.2020</td>
<td>0.50</td>
</tr>
</tbody>
</table>

(Source: WMU Maritime Energy Management Specialization EGY102 Lecture Notes)
IMO Response and Enhancing EE (Reducing CO₂)

- **Technical Measures**
  (Better design of ships and equipment)

- **Operational Measures**
  (Better operation of ships)

- **MBM**
  (Discussions suspended)
Decision Making and Trade-Off

- Cost/Benefit
- Cost (for whom?) (CAPEX, OPEX, Externality?)
- Benefit (for whom?)
- Perspective and decision maker
- Individual solutions and right combination?

(Source: IMO/MEPC-67-INF-9-TARGETS)
Future Ship Propulsion

- From Human to Diesel Engines
- Fuel cells, batteries
- Nuclear (Thorium?)
- Alternative fuels and Renewable (Solar, Wind, LNG, biofuel, Methanol, ..)
- Hybrid (right mix?)

(Ref: Shipping innovation by Niko Wijholst, Tor Wergeland, Figure 407, page 378)
Barriers

• Individual
• Organisational
• Technological
• Economical
• ..........
Other Challenges

• Maritime Digitalisation (big data)

• Autonomous vs. Zero Emission Shipping

• System blindness

• ..
The Latest Springer Book
WMU Studies in Maritime Affairs (Vol.6)

Thank You

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